ON

VOLTAIC ELECTRICITY.

BY THE REV. T. R. ROBINSON, F. T. C. D. M. R. I. A.

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EIGHTEEN years have now passed, since the celebrated Philosopher of Pavia gave a new impulse to physical research by the invention of the apparatus, which bears his name. The observation, which, in the hands of Galvani and others, had remained an insulated and barren fact, or at most subservient to Physiology alone, when developed by his penetrating genius, became the key to a new world; it gave new plumes to the wing of Chemistry; and the result was a career of discovery, which changed the whole science, and has immortalized the fortunate individual, who achieved it. But, while the chemical facts, which were obtained by the pile of Volta, have been prosecuted to the utmost, it is to be regretted, that the instrument itself has been left nearly as it came from its inventor; its theory is unknown; the mode of using it with the greatest effect doubtful; and every construction of

it, which has yet been proposed, defective. These afford an ample field for research; and it is much to be wished, that it were occupied by some person qualified for the task. In the mean time, though prevented by other employments from endeavouring to reap the harvest, I lay before the Academy a few facts, which I have gleaned on the verge of the forbidden ground. They are not of very high importance; but, in the present state of our knowledge, no addition to it, however trifling, is to be despised. There is, I believe, no instance, where a fluid does not constitute one of the elements of a Voltaic combination. But what part does it act in them? that of a conductor of electricity, or a non-conductor? It may seem strange, that so simple a question should remain to be solved; but I am under the necessity of thinking, that it has not yet been satisfactorily answered. The discoverer of the pile, and many other philosophers, are of the first opinion; while the latter seems to be held by Davy, and others of as high authority. To judge from the analogy of that modification of electricity, which is excited by friction in a state of high intensity, water and aqueous fluids should be esteemed conductors; but analogy is not always a safe guide; and, in this instance, I am inclined to distrust it, and to imagine, that they transmit electricity by a very different process from that, by which metals conduct it. If a plate of glass be highly charged, the equilibrium of its sides is frequently restored by an explosion which fractures it. In this case, the electricity certainly passes through the glass; but we do not therefore say, that it is a conductor. If two balls, one communicating with the machine, and the other with the earth, be immersed in oil, the result is the same; but here its fluidity instantly closes the path of the discharge. In fact, when a jar is charged to the utmost, the tendency of the fluid accumulated on its interior to expand

itself is in equilibrio with the cohesion of the glass; and, if this latter were diminished, it would be broken by a charge of less intensity. A slip of glass of good quality, one tenth of an inch square, cannot be pulled asunder by less than thirty pounds; and the cohesion of a square inch of the surface of water is about two grains. I have also found, that a jar, one eighth of an inch thick, cannot bear a charge, which would strike through more than four inches of air; and therefore we may conclude, that, if the particles of glass cohered as weakly as those of water, it would be pierced by a power, which could pass through the ten millionth of an inch of air. It is therefore probable, that this passage of Voltaic electricity through water is merely a series of spontaneous discharges, facilitated by the separation of its elements. This opinion is confirmed by many facts. If a feeble power, as of ten pair of plates very weakly charged, be used to decompose it, gas does not appear instantly on making the connexion. Sometimes more than a second intervenes, and afterwards its evolution is not uniform; but it makes its appearance in bursts, with very perceptible remissions between. If we also consider an observation of Davy, that any bending in the tube between the wires materially impedes the decomposition; and that, if the plates are of moderate size, they afford more of the electric matter than the tube can transmit. And, if we add to this the assertion of Cavendish, that water conducts, even in high intensities, 400,000,000 of times worse than iron, we can scarcely suppose it not to insulate such low powers; for low they must be, as a battery of 2000 pair could only strike through half an inch of a Torricellian vacuum, in which a spark of the common machine would perhaps pervade miles. In a trough of the common construction, I cut off half a zinc plate, and that half of the adjacent copper, which was opposed

to the remainder, and I found, that the power of the apparatus was reduced almost to nothing by this change. It is therefore clear, that the electricity passed through the acid, only when the metallic surfaces were opposed perpendicularly; for, when they were in that position, the instrument regained half its original power. It may also be worth attention, that the law, according to which fluids are decomposed by different Voltaic powers, is very different from that, which obtains in the fusion of wires. Two batteries were used, each containing twenty pair of plates; but the surfaces of the one were double those of the others: and I found, that the lengths of iron wire, which they ignited, were 6 and 1 inches; but, when they were applied to decompose a weak solution of potassa, they gave in six minutes 3.9 and 2 cubic inches of gases. Now there is reason to believe, that the quantities of electricity were, in these instances, as 2 : 1, and the gases evolved were nearly in the same proportion; while it is known, that the action of this fluid on metallic conductors is in the duplicate ratio of its quantity. It also passes through wires of any length with undiminished velocity; for we find, that a battery fuses nearly equal lengths, when the conductors are a few feet long, or when they extend several fathoms. The laws, according to which the decomposing and wire-melting powers vary, with the interval between the electrical poles, are also different. If a battery heat eight inches of wire red hot, it will fuse six nearly; and we may thence infer, that this power is inversely as some high power of the interval; for the temperatures produced must be at least as one to six, as I have shewn in a former communication.* The power of decomposing is inversely as the interval, as ap-

* It is a curious fact, and which I have never seen explained, that the ignition is not uniform throughout the wire. It begins at the points of contact, and spreads over the intervening space, till both meet in the centre, which is not so luminous as the extremes.

pears from the following experiment. Water was decomposed by a given Voltaic power in an apparatus contrived so, that the interval could be changed at pleasure; and it was found, that, when the wires were 1. 45 inches asunder, 53 measures of gas were obtained in 8 minutes; at the distance of 2. 8, 26; and at 4. 3, 16. Now multiplying each product by its corresponding distance, we obtain 76. 8, 72. 4, and 70. 95; so nearly the same, that the difference may be safely referred to the error of observation. If then water and other similar fluids conduct electricity, at low intensities, differently from metals, and only by a succession of spontaneous discharges, we may consider them as non-conductors; and, applying the theory of charged electrics to the plates of acid media, which are elements of the pile, by it and an unquestionable datum, namely, that electricity is evolved, whenever two bodies are connected, one of which is undergoing chemical change, we may investigate the action of this instrument, which is still so obscure. I have attempted this, and have obtained formulas, which represent tolerably the phenomena; but I dare not confide in them till they are verified by further experiments. For, in physical researches, we cannot proceed as in questions of pure geometry; where a few abstract principles are sufficient to open a path, which leads to the most sublime discoveries. In this more difficult field, even the transcendent powers of Bernouilli and Euler have been foiled; and their unsuccessful efforts have enabled the enemies of this exalted science to ridiculeits application to such inquiries.*

* See Euler's Theoria Navalis, his paper on the Strength of Materials, and others;—where, with the most wonderful display of analysis the conclusions are of no practical value, as they are drawn from insufficient data.

If then we wish to enlighten this department of knowledge by the torch of mathematical reasoning, we must beware of proceeding from data either trivial or false; and must store our minds with experiments, by which we may try our conclusions. For this I am not yet prepared; and, before I conclude, I shall mention some facts, connected with the Voltaic apparatus, which are not generally known. The intervals between the plates should be as small as possible; for, according to my view of the subject, the plates of fluid are charged: and, with a given intensity, the charge is inversely as the thickness, and experience confirms this conclusion; for it is known, that the pile, notwithtsanding its various imperfections, is much more powerful than the trough, while the series is small. Nor is any thing gained, by making the cells large, towards the longer continuance of electrical action; as a battery ceases to act powerfully long before all the acid contained in them is saturated. This diminution of effect is in part owing to the presence of a salt of zinc; for, if we add a little chlorid of zinc to a mixture of hydrochloric acid and water, which would have produced a vivid effect, it is rendered nearly inert. But it is still more occasioned by the presence of hydrogen gas; which virtually diminishes the surfaces of the plates, and of course lessens the quantity of electricity. The troughs, which I have already mentioned as capable of fusing 6 inches of fine iron wire when first charged, after 3 minutes could only ignite one. The plates were then raised, and, after two hours, when they were again immersed, it ignited $3\frac{1}{2}$; and this difference was not owing to any subsidence of the metallic salt, for the fluid was agitated in the cells before the plates were let down. The relative values of these impediments may be estimated from the following experiment. A trough, charged with water, containing $\frac{1}{70}$ of hydrochloric acid, gave, by decomposing solution of

potassa, in the first five minutes, 0. 8 of a cubic inch of gases; in the next five, 0. 25. It was recharged, and gave, in the first five, 1. 0. The plates were then raised for 5 more, and, in the next five, it gave 0. 45; but, had the gas not been allowed time to escape from the fluid in the cells, it would have afforded only 0. 3, and the hydrogen would have diminished the effect $\frac{1}{3}$.

For the same reason we do not find, that we gain a proportional augmentation of power by increasing the strength of the acid mixture. With $\frac{1}{70}$ of hydrochloric acid, I obtained 0. 8; with $\frac{1}{60}$, 0. 875; and with $\frac{1}{50}$, 1. 0, where the numbers proportional to the quantities of acid are 8, 9. 3, and 11. 2. Experiments have been made by me on constructing batteries of large surface; but I have not obtained any striking results. Where the trough is large, much difficulty is usually experienced in making it water-tight; but the form which I used is very convenient. A cell is formed of thin copper soldered, so as to hold the acid; from the middle of one of its broad sides proceeds a slip of copper, which is connected with a zinc plate, supported in a similar adjacent cell, so as not to be in contact with its sides. (See the Plate.) The series in this way may be continued ad libitum; and, from the double surfaces, which are effective in this construction, the arrangement is extremely powerful. In the same plate is exhibited another arrangement, which I have found convenient: its construction is obvious, without any description. I endeavoured, though without success, to obtain both quantity and intensity of electricity without the enormous expence of a series of large plates. It seemed possible, that, as the intensity depended on the number, and the quantity on the size, if the central plates were small, and their magnitude gradually augmented to the extremes, this result might be obtained.

The central zinc plate was half the size of those at the extremes, and they were gradually increased on both sides; each copper plate being equal to the zinc opposed to it. When I first tried the battery, it fused a wire equivalent to the size of the extreme plates; but, as I never obtained a similar result, I must conclude, that this was a deception; for the power of the apparatus, whether estimated by fusion or decomposition, did not exceed that of a series of plates equal to the least in it. It remains to apologize for obtruding on the Academy these remarks in their present imperfect state. I could wish to have prosecuted the subject further; but, I trust, that, even at present, they may be found not unworthy of acceptance. To me at least the information, which they convey, is new; and, if they should excite others to come forward in a similar manner, I shall conceive, that they have not been penned in vain. The quantity of knowledge which is lost to the world by the reserve of individuals, who are reluctant to publish any thing unfinished or unconnected, is deplorable. No person ever ranged in the course of Experimental Philosophy, who has not found some fact unnoticed by others, something peculiar to reward him for his labour. How many interesting details would have been unknown to us, had not Wollaston been a friend of the editors of certain periodical works! How many important discoveries are buried in the grave of Tennant! Nor is this true only of the stars of the Chemical sky; and he who knows a single fact in Physics, which is not generally known, is wanting in his duty to science and mankind, if he withhold it either through indolence or modesty.